# Natural Attenuation of Coal Combustion Waste in River Sediments

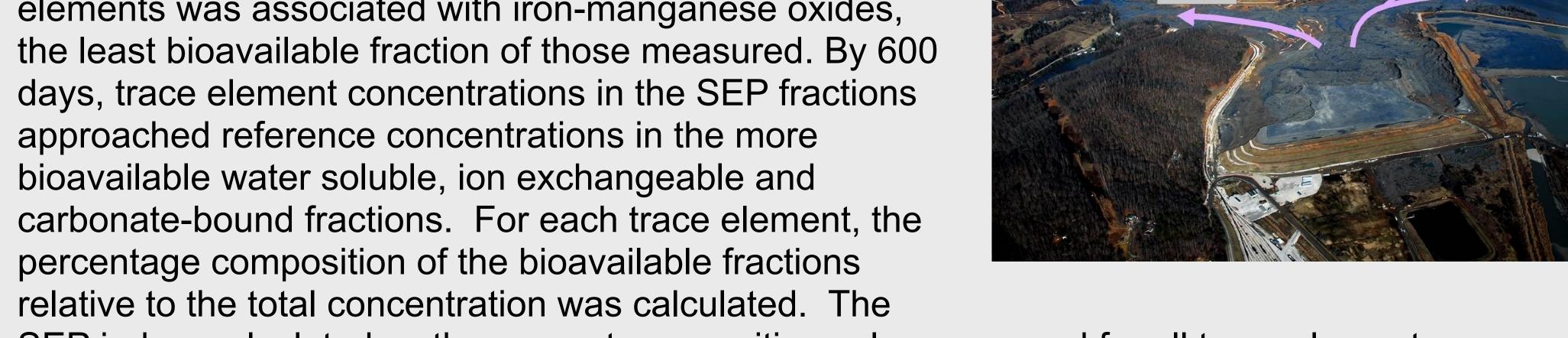
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#### Abstract

The weathering of coal combustion waste in a lotic environment was assessed following the Tennessee Valley Authority (TVA) fly ash release of 2008 (Kingston, TN). Sampled materials included stockpiled TVA ash, ash-laden sediment at 180 days and at least 600 days after the release, and reference sediment (≤1% ash content) upstream of the release site. Percent ash and total recoverable concentrations of heavy metals and metalloids in sediment were measured. Arsenic and selenium in sediment were positively correlated with percent ash. For samples collected 180 days after the release, total concentrations of trace elements measured downstream of the release were greater than reference levels but less than concentrations measured in stockpiled ash. Total concentrations of trace elements remained elevated in ash-laden sediment after 600 days. The percent ash in sediment was not significantly different between sampling events.

A sequential extraction procedure was used to speciate selected fractions of arsenic, copper, lead, nickel and selenium in decreasing order of

bioavailability. Concentrations of trace elements in sequentially-extracted fractions were one to two orders of magnitude lower than total recoverable trace elements. The bulk of sequentially extractable trace elements was associated with iron-manganese oxides, the least bioavailable fraction of those measured. By 600 days, trace element concentrations in the SEP fractions approached reference concentrations in the more bioavailable water soluble, ion exchangeable and carbonate-bound fractions. For each trace element, the percentage composition of the bioavailable fractions



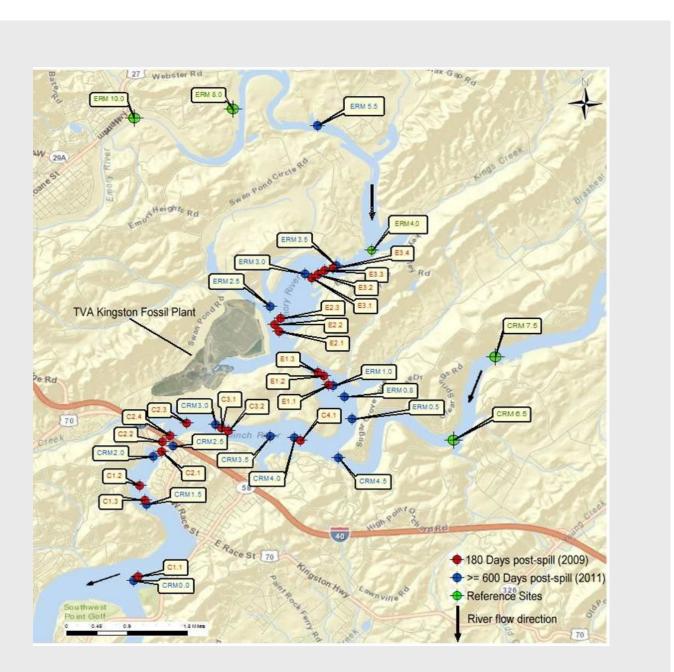
SEP index, calculated as the percent composition values summed for all trace elements across the four SEP fractions, was significantly lower at 600 days compared to 180 days and approached reference observations. These results document the natural attenuation of coal combustion waste in sediment resulting from the loss of bioavailable trace elements over time.

#### Introduction

- Tennessee Valley Authority Kingston Ash Recovery Project
- Large release of fly ash at the Kingston fossil plant
- Approximately 4 million m<sup>3</sup> ash released from containment area

#### Residual Ash in Rivers

- Dredging in Emory River (May 2009 to June 2010)
- Mechanical excavation in embayments (June 2010 to June 2013)
- •~2.7 million m<sup>3</sup> of ash in sediment removed from Emory River
- •~1.9 million m<sup>3</sup> removed from embayments
- •~380,000 m<sup>3</sup> of ash remaining, mostly in Emory River



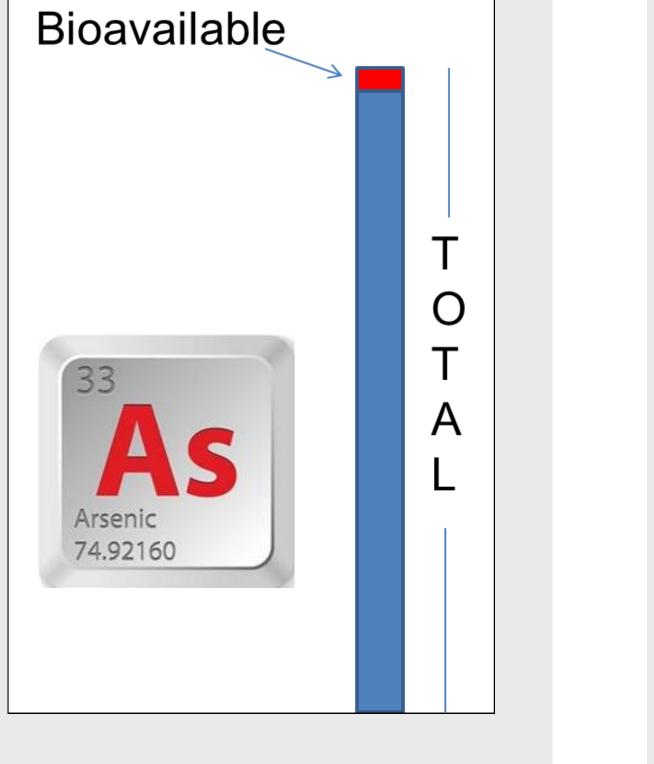
#### **Trace Elements**

- Coal ash contains toxic trace elements such as: Arsenic, Copper, Lead, Nickel, Selenium
- These elements present a potential risk to ecological receptors

# Bioavailability

- Bioavailability defined by how tightly trace elements are bound within sediment geochemical matrices
- More tightly bound is less bioavailable
- Of total trace element concentrations, most associated with recalcitrant mineral phases • e.g., 97% of total arsenic associated with un-extractable fraction



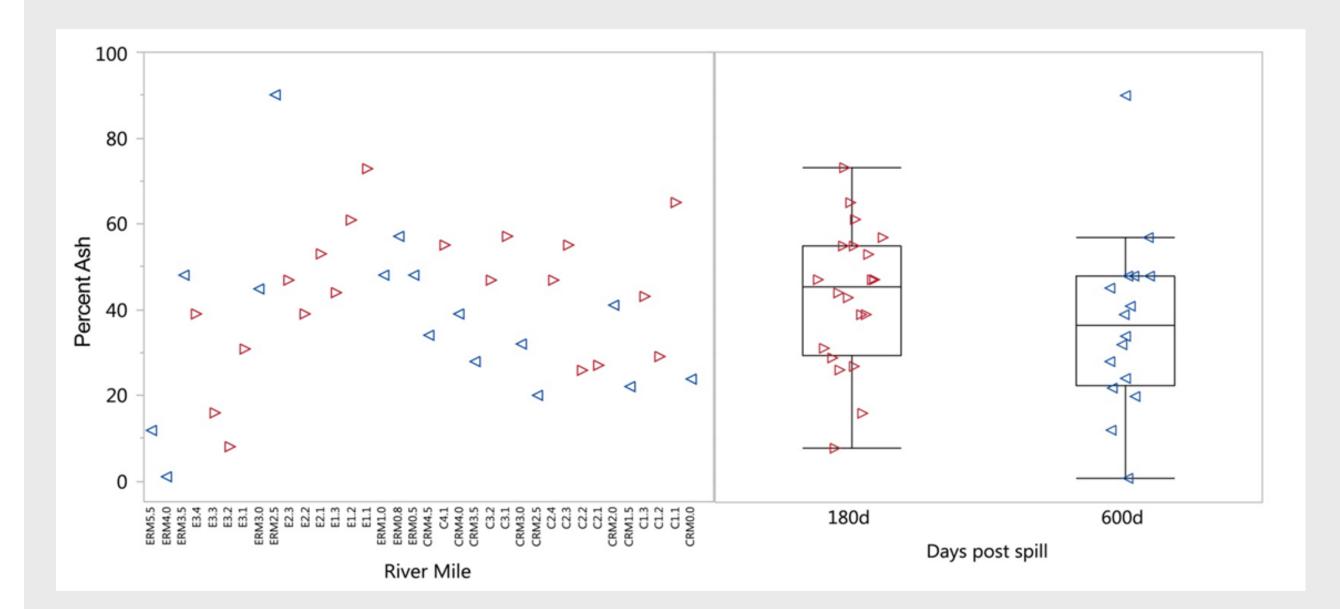


### **SEP Index**

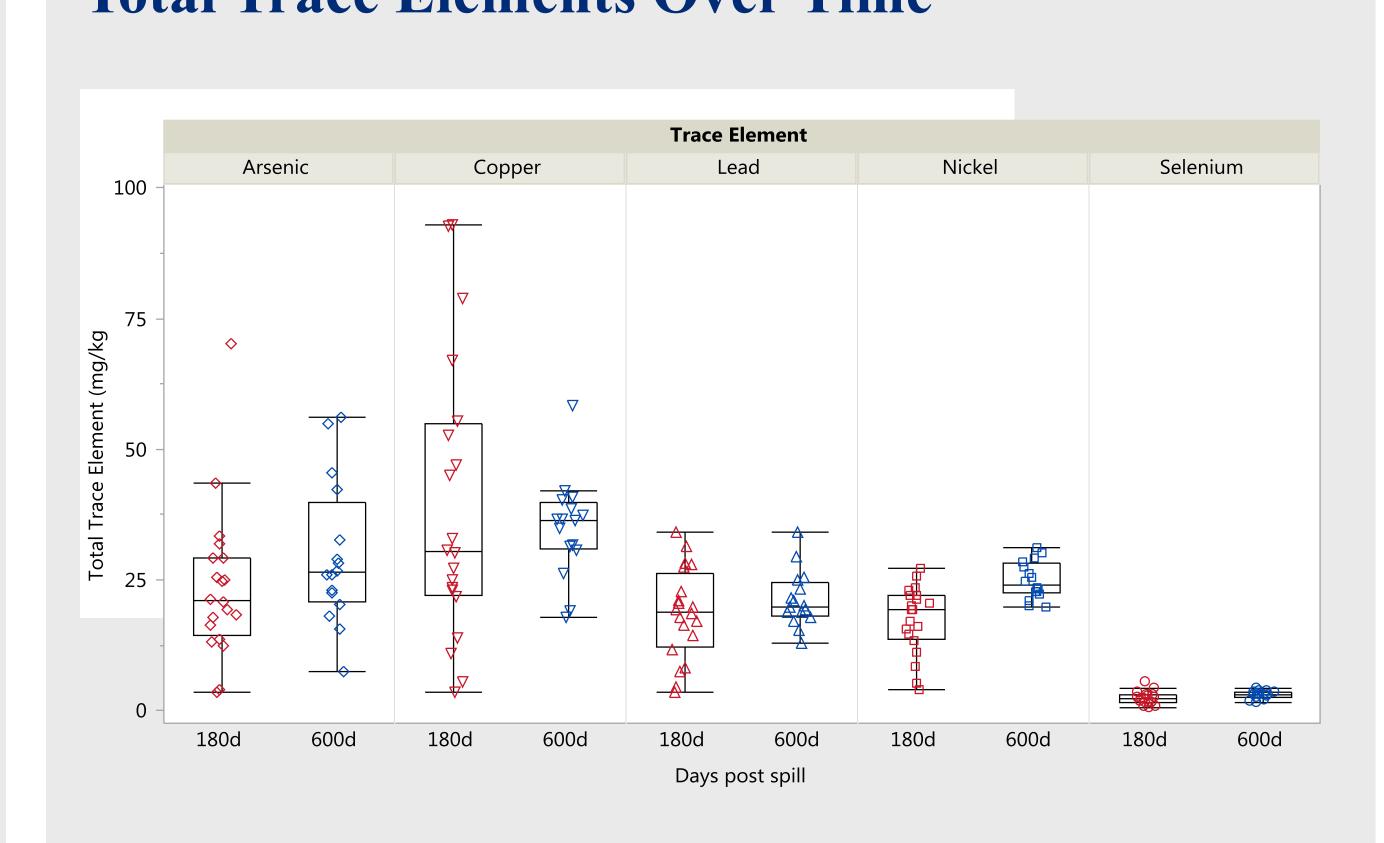
- Percent composition that each SEP fraction represents of the total trace element sediment concentration; calculated by the average concentration for the SEP fraction, divided by the average total recoverable trace element, multiplied by 100.
- The bioavailable fractions of all the trace elements was calculated by summing the SEP fractions for all five metals (20 total SEP fractions).
- This SEP index provided a holistic means of assessing the distribution and the dynamics of trace element partitioning over

Correlated Ash and As, Se

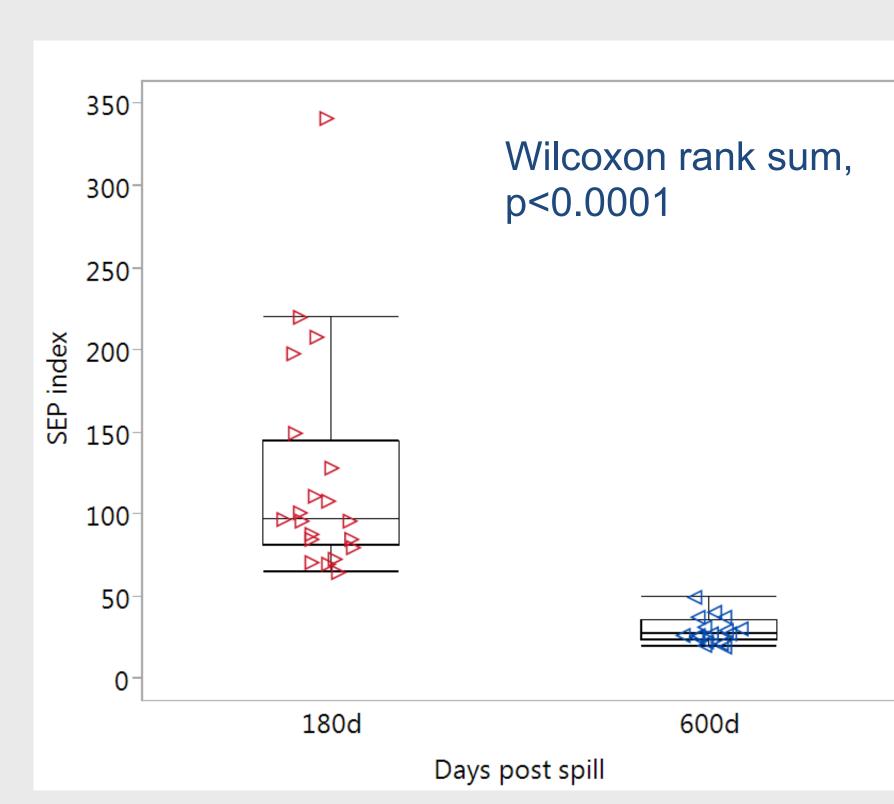
## Percent Ash: River Mile and Time



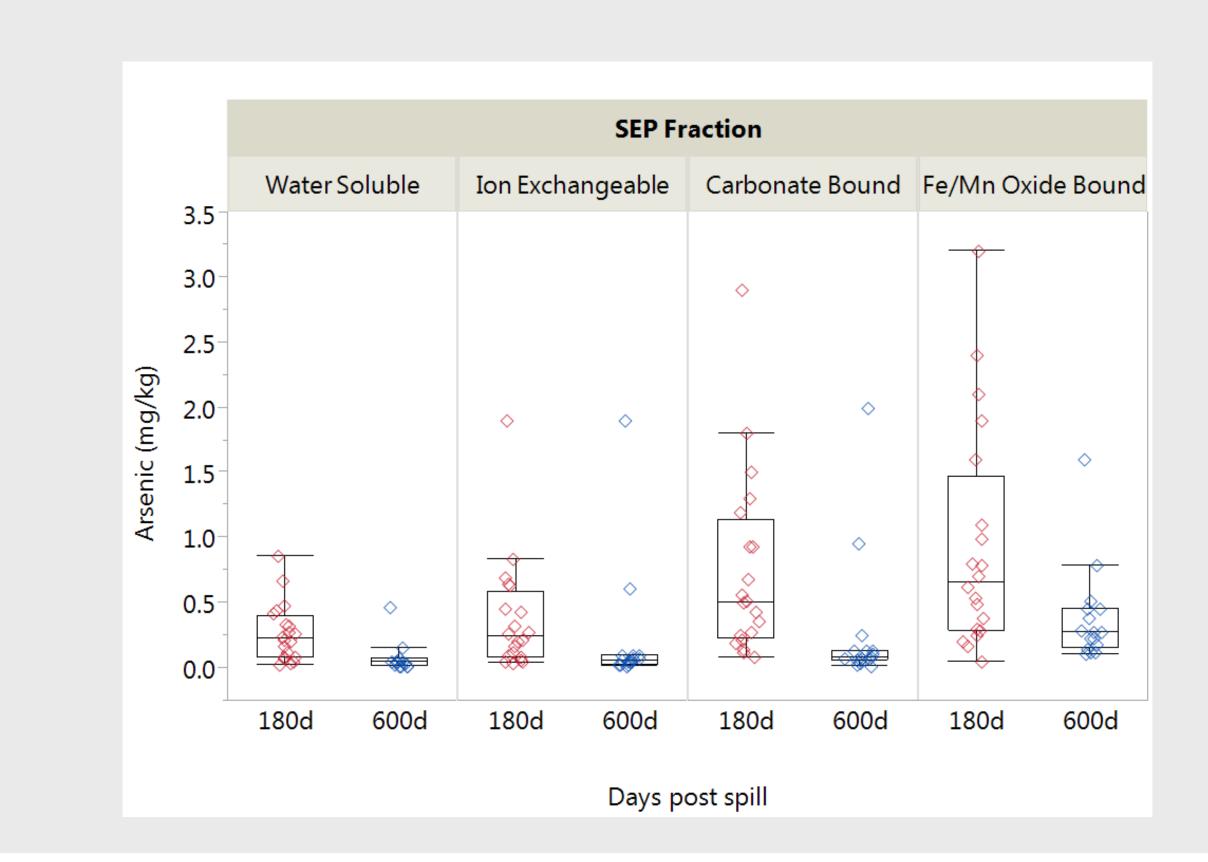
# **Total Trace Elements Over Time**



# **SEP Index: Sequentially Extracted Trace Elements**



# Sequentially-Extracted Arsenic



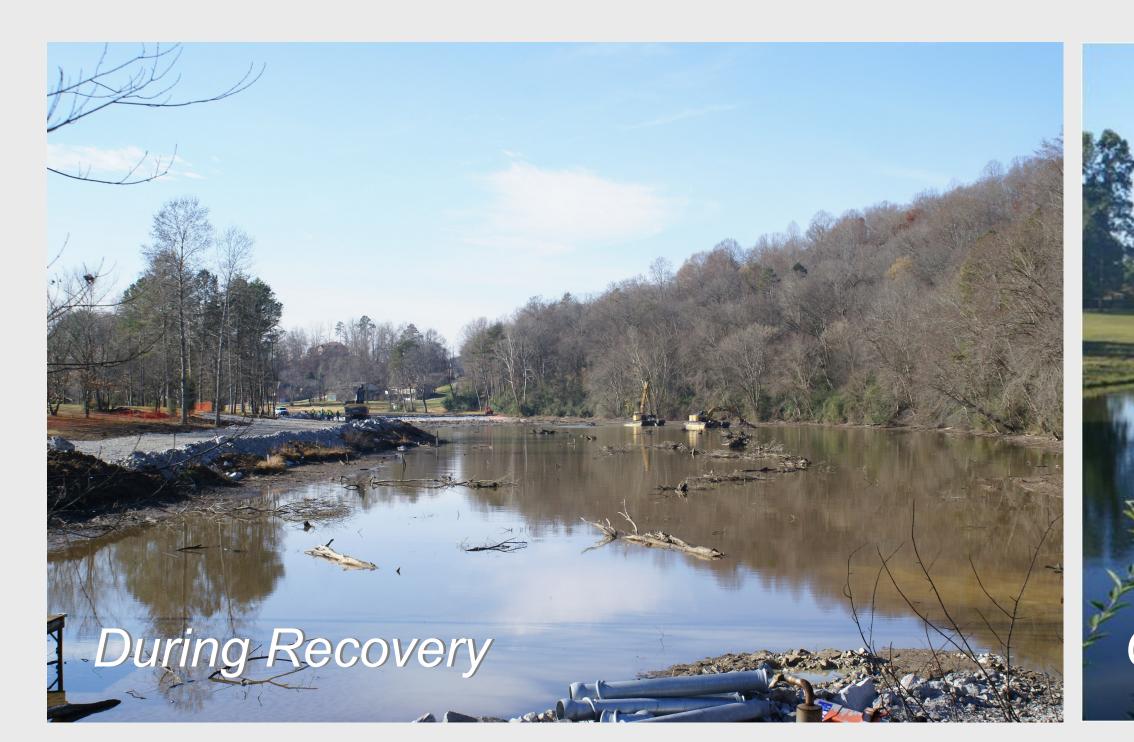
#### **Trace Element Distribution**

	Arsenic	Copper	Nickel	Lead	Selenium
Total Concentrations (mg/kg)	31	36	25	21	3.1
SEP Concentrations	0.98	0.97	2.4	0.78	0.33
Bioavailable (SEP) Percent of Total	3%	3%	11%	4%	11%

Concentrations are in units of mg/kg dry weight.

Concentration represent sediments collected after at least 600 days following the ash spill.

- Arsenic and selenium are positively correlated with percent ash in sediment
- Percent ash in sediment and total trace elements are not significantly different between time
- Risk based on exposure to total trace elements is unnecessarily conservative
- Bioavailable trace elements are a small fraction (between 3% and 11%) of total trace elements
- Bioavailable trace elements are significantly lower in concentration 600 days following the ash
- Exposure to naturally-attenuated coal combustion waste in sediment represents negligible risk







#### Contact

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